NEXAFS study of graphene/hexagonal boron nitride heterointerface

Shiro Entani[1], Masaru Takizawa[2], Hiroshi Naramoto[1], and Seiji Sakai[1]

1) Quantum Beam Science Directorate, National Institutes for Quantum and Radiological Science and Technology, Tokai, Ibaraki 319-1195, Japan

2) Department of Physical Sciences, Faculty of Science and Engineering, Ritsumeikan University, Kusatsu, Shiga 525-8577, Japan

1. Introduction

Graphene has proved interesting for nanoelectronics and spintronics. Direct growth of graphene on insulator substrates is currently one of the most important subjects for development of graphene-based devices, because the transfer process degrades the electron and spin transport properties of graphene by the introduction of defects, impurities and cracks. In this study, employing chemical vapor deposition (CVD), single-layer graphene (SLG) was directly grown on a hexagonal boron nitride (*h*-BN) surface which is also grown on SiO_2 by CVD technique. The crystallinity of both SLG and *h*-BN was inspected by near edge X-ray absorption fine structure (NEXAFS) spectroscopy.

2. Experimental

The SLG/*h*-BN heterostructure was fabricated using a custom designed vacuum furnace with a base pressure of 10^{-6} Pa. The *h*-BN and SLG films were grown by exposing the SiO_2 surface to ammonia borane and methanol vapors at the substrate temperature of 1173 K. NEXAFS measurements were conducted at the BL-8 of SR center at Ritsumeikan University. NEXAFS spectra of the samples were measured in partial electron yield by a micro-channel plate detector with retarding grids. The incident angles of SR with respect to the surface plane were set to 30° and 90° in order to obtain information on the orientations of SLG and *h*-BN on the substrate from the changes of the π* and σ* peaks of the C and B *K*-edge spectra.

3. Results and Discussion

Figure 1 shows the C K-edge spectra of SLG/*h*-BN/SiO_2. The peaks at around 285.6 eV and 287.3 eV are assigned to the excitation of C 1*s* → π*(C=C) and σ*(C-H), respectively. It is found that the intensity of the π* peak was significantly decreased in the normal X-ray incidence. This indicates that the grown graphene sheet is parallel to the surface plane. It can

be considered that the graphene film with high crystallinity and orientation has been successfully grown directly on the *h*-BN surface.

The crystallinity of *h*-BN before and after the SLG growth was inspected by employing B and N *K*-edge NEXAFS. Figure 2 shows B *K*-edge spectra of *h*-BN/SiO_2 and SLG/*h*-BN/ SiO_2. The peak at around 192.0 eV is derived from the excitation of B 1s $\rightarrow$ π*. It is found that the intensity of the π* peak shows significant incident angle dependence as it can be seen in the C *K*-edge spectra. This indicates that the *h*-BN sheet is also parallel to the surface plane. The incident angle dependence becomes more remarkable in SLG/*h*-BN/SiO_2, which suggests that the orientation of the h-BN sheet is improved by the SLG growth. The arrows in Fig. 2 (192.5, 193.3, 194.0 eV) show the peaks attributed to the oxidation of *h*-BN ($BN_{3-x}O_x$, x = 1, 2, 3), which occurs by the substitution of nitrogen atoms by oxygen atoms.[1] It can be considered that the exposure of the methanol vapor which is used as a precursor for the SLG growth provides a modicum of the oxidation in *h*-BN.

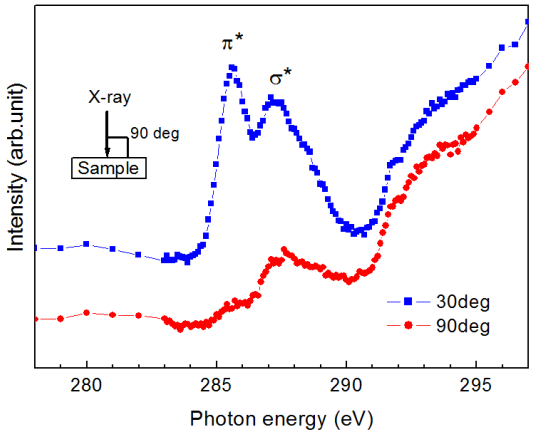

Fig. 1 C K-edge spectra of SLG/*h*-BN/SiO_2.

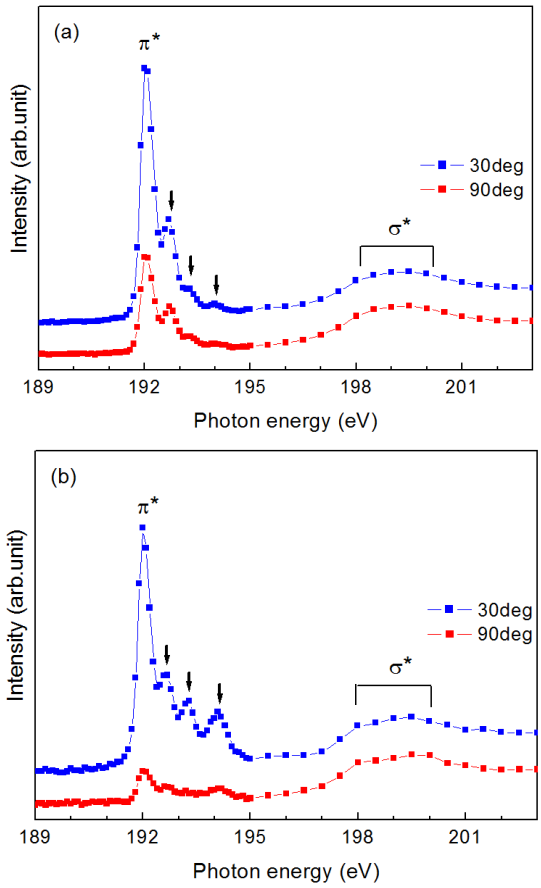

Fig. 2 B K-edge spectra of (a) *h*-BN/SiO_2 and (b) SLG/*h*-BN/SiO_2.

4. Conclusions

We have succeeded in synthesizing the SLG/*h*-BN heterostructure by the direct CVD growth on SiO_2. We believe that the present study provides an important basis for precise control of electron and spin transport properties of graphene, and leads to the development of graphene-based devices.

References

[1] K.A. Simonov *et al*., Surf. Sci. **606**, 564 (2012).